into Kuskokvim Bay, Behring Sea, as believing that the mammoth, whose tusks they constantly find came from the east, and were destroyed by the spells of their *shaman*.

In the kitchen-middens of the deserted Esquimaux villages of Jacobshafn, West Greenland, Dr. Oberg discovered bones of the Walrus and *Cystophora cristata*, which no longer ventures into this ice-blockaded fjord; and also of the bear *Ursus maritimus*, which is now rarely seen south of the Waigat, associated with arrow-heads, stone flakes, and scrapers, of clear quartz crystals and green jasper (*angmak* of the Greenlanders), found in the basalt of Disco.

CHARLES E. DE RANCE

(*To be continued.*)

ON ATTRACTION AND REPULSION RESULTING FROM RADIATION

AT the Royal Society *conversazione* the other evening the most interesting object exhibited was, beyond all doubt, the radiometer of Mr. Crookes. Mr. Crookes' discovery is of so much importance that our readers will be glad to have an abstract of a paper on the subject, recently read by Mr. Crookes at the Royal Society. It was the second part of a paper which the author sent to that Society in August 1873.

Mr. Crookes commences by describing improvements which he has made in the Sprengel pump, and in various accessories which are necessary when working at the highest rarefactions. He describes different new forms which enable the phenomena of repulsion by radiation to be observed and illustrated. A bulb three inches diameter is blown at the end of a glass tube eighteen inches long. In this bulb a fine glass stem with a sphere or disc of pith, &c., at each end is suspended by means of a cocoon fibre. The whole is attached to the Sprengel pump in such a way that it can be perfectly exhausted, and then hermetically sealed. Besides pith, the terminals may be made of cork, ivory, metal, or other substance. During exhaustion several precautions have to be taken, and to get the greatest delicacy in an apparatus of this kind, there is required large surface with a minimum of weight. An apparatus constructed with the proper precautions is so sensitive to heat that a touch with the finger on a part of the globe near one extremity of the pith will drive the index round over 90°, whilst it follows a piece of ice as a needle follows a magnet. With a large bulb very well exhausted and containing a suspended bar of pith, a somewhat striking effect is produced when a lighted candle is placed about two inches from the globe. The pith-bar commences to oscillate to and fro, the swing gradually increasing in amplitude until the dead centre is passed over, when several complete revolutions are made. The torsion of the suspending fibre now offers resistance to the revolutions, and the bar commences to turn in the opposite direction. This movement is kept up with great energy and regularity as long as the candle burns.

Mr. Crookes discusses the action of ice, or a cold substance, on the suspended index. Cold being simply negative heat, it is not at first sight obvious how it can produce the opposite effect to heat. The author, however, explains this by the law of exchanges, and shows that attraction by a cold body is really repulsion by radiation falling on the opposite side. According to the same law, it is not difficult to foresee what will be the action of two bodies, each free to move, if they are brought near to each other in space, and if they differ in temperature either from each other or from the limiting walls of the space. The author gives four typical cases, with experiments, which prove his reasoning to be correct.

Experiments are described with the object of ascertaining whether the attraction by heat, which, commencing at the neutral point, increases with the density of the enclosed air, will be continued in the same ratio if the apparatus is filled with air above the atmospheric pressure. This is found to be the case. Various experiments are described with bulb-apparatus, in which the bulb is surrounded with a shell containing various adiathermous liquids, and also with a shell of vacuum. In all cases radiation passed through, producing the normal action of attraction in air and repulsion in a vacuum.

Mr. Crookes next describes a form of apparatus by which measurable results are attainable. It consists of a long glass tube, with a wider piece at the end. In it is suspended a lump of magnesium by a very fine platinum wire, the distance between the point of suspension and the centre of gravity of the magnesium bob being 39·14 inches. Near the magnesium is a platinum spiral, capable of being ignited by a voltaic battery. Observations of the movement of the pendulum were made with a telescope with micrometer eyepiece. With this apparatus a large series of experiments are described, starting from air of normal density, and working at intermediate pressures up to the best attainable vacuum.

With this apparatus it was found that a candle-flame brought within a few inches of the magnesium weight, or its image focussed on the weight, and alternately obscured and exposed by a piece of card at intervals of one second, will soon set the pendulum in vibration when the vacuum is very good. A ray of sunlight allowed to fall once on the pendulum will immediately set it swinging.

The form of apparatus is next described, which the author has finally adopted, as combining the greatest delicacy with facility of obtaining accurate observations, and therefore of getting quantitative as well as qualitative results. It consists of a glass apparatus in the shape of an inverted T, and containing a horizontal glass beam suspended by a very fine glass thread. At the extremities of the beam are attached the substances to be experimented on, and at the centre of the beam is a small mirror from which a ray of light is reflected on to a graduated scale. The advantage which a glass thread possesses over a cocoon fibre is that the index always comes accurately back to zero. In order to keep the luminous index at zero, except when experiments are being tried, extreme precautions must be taken to keep all extraneous radiation from acting on the torsion-balance. The whole apparatus is closely packed all round with a layer of cotton-wool about six inches thick, and outside this is arranged a double row of Winchester quart bottles filled with water, spaces only being left for the radiation to fall on the balance, and for the index ray of light to get to the mirror.

However much the results may vary when the vacuum is imperfect, with an apparatus of this kind they always agree amongst themselves when the residual gas is reduced to the minimum possible; and it is of no consequence what this residual gas is. Thus, starting with the apparatus full of various vapours and gases, such as air, carbonic acid, water, iodine, hydrogen, ammonia, &c., at the highest rarefaction there is not found any difference in the results which can be traced to the residual gas. A hydrogen vacuum appears the same as a water or an iodine vacuum.

With this apparatus the effect of exposing torsion-balance to a continuous radiation is described, and the results are shown graphically. The effect of a short (11·3 seconds) exposure to radiation is next described, and the results are given in the form of a Table.

In another Table are given the results of experiments in which a constant source of radiation was allowed to act upon one end of the torsion-beam at a distance of 140 or 280 millims., various substances being interposed. The sensitiveness of this apparatus to heat-rays appears to be greater than that of an ordinary thermo-multiplier. Thus

the obscure heat-rays from copper at 100°, passing through glass, produce a deflection on the scale of 3·25, whilst under the same circumstances no current is detected in the thermo-pile. The following substances are used as a screen, and the deflections produced, when the source of radiation is magnesium-wire, a standard candle, copper at 400° and copper at 100°, are tabulated :—

Rock-salt, 20 millims. thick ; rock-crystal, 42 millims. thick ; dark smoky talc ; plate glass of various thicknesses, both white and green ; a glass cell containing 8 millims. of water ; a plate of alum 5 millims. thick ; calc-spar, 27 millims. thick ; ammonio-sulphate of copper, opaque to rays below E, ditto opaque to rays below G.

Mr. Crookes considers that these experiments show that the repulsion is not entirely due to the rays usually called heat, *i.e.* to the extremo- and ultra-red of the spectrum. Experiments have been tried with the electric and the solar spectrum formed with a quartz train, which prove the action to be exerted by the luminous and ultra-violet rays. Some numerical data have been obtained, but unfavourable weather has prevented many observations being made with the solar spectrum.

The barometric position of the neutral point dividing attraction from repulsion is next discussed. The position of this point varies with the density of the substance on which variation falls, the ratio of its mass to its surface, its radiating and conducting power for heat, the physical condition of its surface, the kind of gas filling the apparatus, the intensity of radiation, and the temperature of the surrounding atmosphere. The author is inclined to believe that the true action of radiation is repulsion at any pressure, and that the attraction observed when the rarefaction is below the neutral point is caused by some modifying circumstances connected with the surrounding gas, but not being of the nature of air-currents. The neutral point for a thin surface of pith being low, whilst that for a moderately thick piece of platinum being high, it follows that at a rarefaction intermediate between these two points pith would be repelled, while platinum was attracted by the same beam of radiation. This is proved experimentally ; and an apparatus showing simultaneously attraction and repulsion by the same ray of light is described and illustrated in the paper.

Mr. Crookes concludes his paper with a discussion of the various theories which have been adduced in explanation of these phenomena. The air-current and electrical theory are considered to have been abundantly disproved. The following experiment is given to show that Prof. Osborne Reynolds's hypothesis of the movements due to evaporation and condensation at the surface will not account for all the facts of the case, and that, therefore, he has not hit upon the true explanation. A thick and strong bulb was blown at the end of a piece of very difficultly fusible green glass, specially made for steam-boiler gauges. In it was supported a thin bar of aluminium at the end of a long platinum wire. The upper end of the wire was passed through the top of the tube and well sealed in, for electrical purposes. The apparatus was sealed by fusion to the Sprengel pump, and exhaustion was kept going on for two days, until an induction-spark refused to pass across the vacuum. During this time the bulb and its contents were several times raised to a dull red heat. At the end of two days' exhaustion the tube was found to behave in the same manner as, but in a stronger degree than, it would in a less perfectly exhausted apparatus, viz., it was repelled by heat of low intensity and attracted by cold. A similar experiment was next tried, only water was placed in the bulb before exhaustion. The water was then boiled away *in vacuo*, and the exhaustion continued, with frequent heating of the apparatus to dull redness, for about forty-eight hours. At the end of this time the bar of aluminium was found to behave exactly the same as the one in the former experiment, being repelled by radiation.

It is impossible to conceive that in these experiments sufficient condensable gas or vapour was present to produce the effects Prof. Osborne Reynolds ascribes to it. After the repeated heating to redness of the highest attainable exhaustion, it is impossible that sufficient vapour or gas should condense on the movable index to be instantly driven off by the warmth of the finger with recoil enough to drive backwards a heavy piece of metal.

Whilst objecting to the theories already advanced as not accounting for all the facts of the case, Mr. Crookes confesses that he is not as yet prepared with one to put in their place. He wishes to avoid giving any theory on the subject until a sufficient number of facts have been accumulated. The facts will then tell their own tale. The conditions under which they invariably occur will give the laws, and the theory will follow without much difficulty.

THE FATAL BALLOON ASCENT

THE readers of NATURE are no doubt aware of the fatal result of the recent ascent of the balloon *Zenith* ; the following authentic details at first hand will no doubt be of interest :—

CIRON (Indre), *April* 17.

The *Zenith* was sent up on the 15th of April in order to determine the quantity of carbonic acid contained in the atmosphere at an altitude of 24,000 feet. The "let go" was given at twenty-five minutes to twelve A.M. The captain was M. Sivel, and there were only two passengers, M. Gaston Tissandier and M. Crocé-Spinelli. The ascent took place gradually in a slight E.N.E. wind, the sky being blue but vaporous. The rate of ascent was calculated to be nine feet per second, but diminished gradually. Shortly after one o'clock the altitude obtained was 22,800, and the passengers were quite well, although feeling weak. The inhalation of oxygen produced good restorative effects when tried. Then a consultation took place, and the *Zenith* being in equilibrium, a quantity of ballast was thrown overboard. M. Tissandier then fainted, and is ignorant of what was felt by his friends.

At eighteen minutes past two he was awakened by M. Crocé-Spinelli warning him to throw over ballast as the balloon was fast descending. He obeyed mechanically, and at the same time Crocé-Spinelli threw overboard the aspirator, weighing eighty pounds. Tissandier then wrote in his book a few disconnected words, and again fell asleep for about an hour. When he awoke, the balloon was descending at a terrific rate ; no more ballast was left to be thrown away, and his two friends were suffocated. Their faces had turned black, and the blood was flowing from their mouth and nose. They were evidently dead. It was a terrible situation.

The only resource was to cut the grapnel rope a little before the instant when the car should strike the ground, which Tissandier did with astonishing coolness. The wind had increased in strength, and Tissandier was obliged to tear open the balloon in order to stop it. It was caught on a hedge in a commune of Indre, called Ciron, 190 miles S.S.W. from Paris.

The tragic fate of Sivel and Spinelli is to be ascribed to the fatal resolution of accomplishing, at any price, a height of 24,000 feet, but mainly, no doubt, to the throwing out of the aspirator, which will be discovered somewhere perhaps unbroken, as it had been provided with a parachute.*

The only instruments broken are the potash tubes for the absorption of carbonic acid. The experiment had been tried successfully ; two aspirators had been used, but the tubes were not lodged in their proper case.

Careful readings were taken with the thermometer, and,

* According to the *Times* correspondent, this and other things have been found.